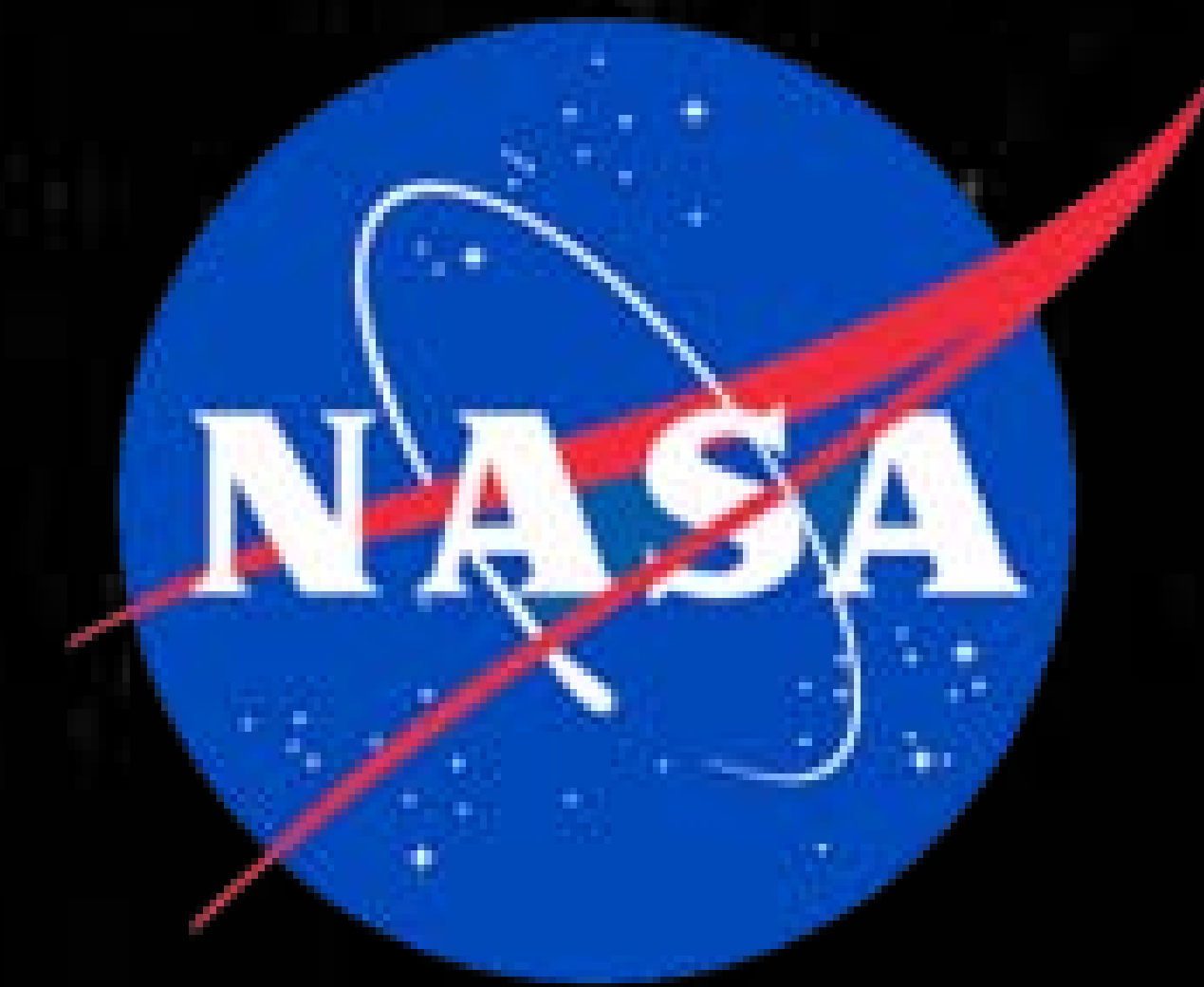


# Selecting Tasks for Evaluating Human Performance as a Function of Gravity



Jason R. Norcross<sup>1</sup> and Michael L. Gernhardt<sup>2</sup>

<sup>1</sup>Wyle Integrated Science and Engineering Group, Houston, TX; <sup>2</sup>NASA Johnson Space Center, Houston, TX

## INTRODUCTION

A challenge in understanding human performance as a function of gravity is determining which tasks to research. Initial studies began with treadmill walking, which was easy to quantify and control. However, with the development of pressurized rovers, it is less important to optimize human performance for ambulation as pressurized rovers will likely perform gross translation for them. Future crews are likely to spend much of their extravehicular activity (EVA) performing geology, construction, and maintenance type tasks. With these types of tasks, people have different performance strategies, and it is often difficult to quantify the task and measure steady-state metabolic rates or perform biomechanical analysis.

For many of these types of tasks, subjective feedback may be the only data that can be collected. However, subjective data may not fully support a rigorous scientific comparison of human performance across different gravity levels and suit factors. NASA would benefit from having a wide variety of quantifiable tasks that allow human performance comparison across different conditions. In order to determine which tasks will effectively support scientific studies, many different tasks and data analysis techniques will need to be employed. Many of these tasks and techniques will not be effective, but some will produce quantifiable results that are sensitive enough to show performance differences.

One of the primary concerns related to EVA performance is metabolic rate. The higher the metabolic rate, the faster the astronaut will exhaust consumables. The focus of this poster will be on how different tasks affect metabolic rate across different gravity levels.

## PURPOSE

To evaluate human metabolic performance as a function of gravity using tasks relevant to future Exploration EVA architectures.

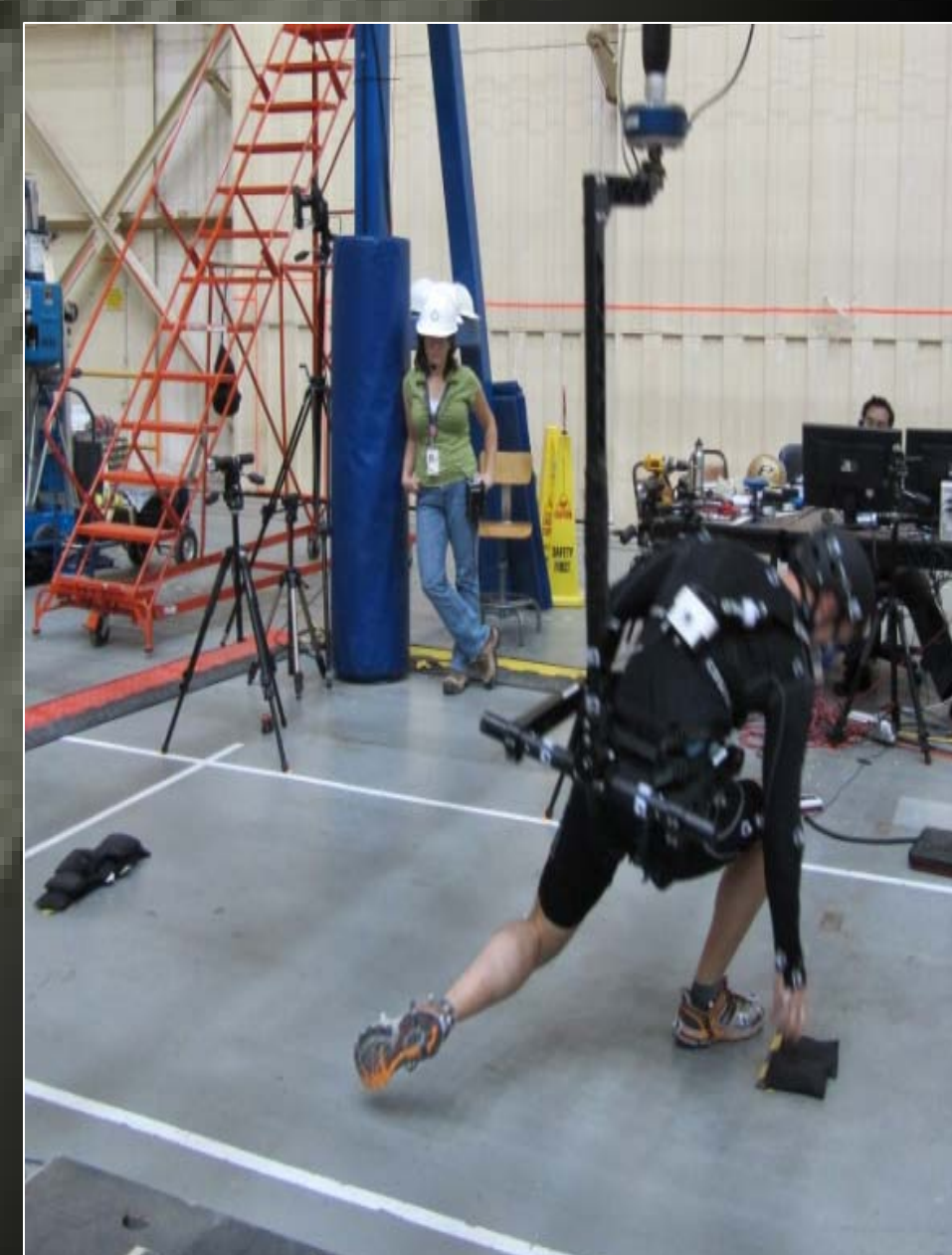
## METHODS

Ten subjects (3 women, 7 men; 38.0 ± 9.3 yrs; 178.1 ± 10.3 cm; 79.5 ± 34.5 kg) completed 5 different tasks shirt-sleeved at 1-g, 3/8-g, and 1/6-g. Offloaded conditions were achieved via the active response gravity offload system (ARGOS) using a gimbal support structure that interfaced to the subject via a modified adjustable brief style harness (Amspec Model # FH0102MBRG). The examined simulated EVA tasks were weight transfer, shoveling, treadmill walking, treadmill running, and treadmill incline walking. Weight transfer involved moving 10 weight bags (each ~ 2.5 kg) one at a time to a point 2.5 m from the starting position and then returning each bag to the starting position. Metabolic cost for the weight transfer task was reported as liters O<sub>2</sub> consumed to complete the task. Shoveling involved moving a substrate (deer corn) from one receptacle to another. Shoveling was performed for 3 minutes with metabolic cost reported as L O<sub>2</sub> consumed per 100 kg substrate shoveled. Walking (3.0 km/h), running (7.5 km/h), and incline walking (3.0 km/h, 20%) were completed on an oversized research treadmill (Vacumed Model # 13610). Speeds were selected to bound the range of expected traverse speeds and to be in the range of previous test data. Treadmill tasks were performed for 3 minutes with reported oxygen consumption (VO<sub>2</sub>) averaged over the last 2 minutes. Statistical analysis was performed via repeated measures ANOVA. Metabolic data collection was performed with a Cosmed K4b2 system.

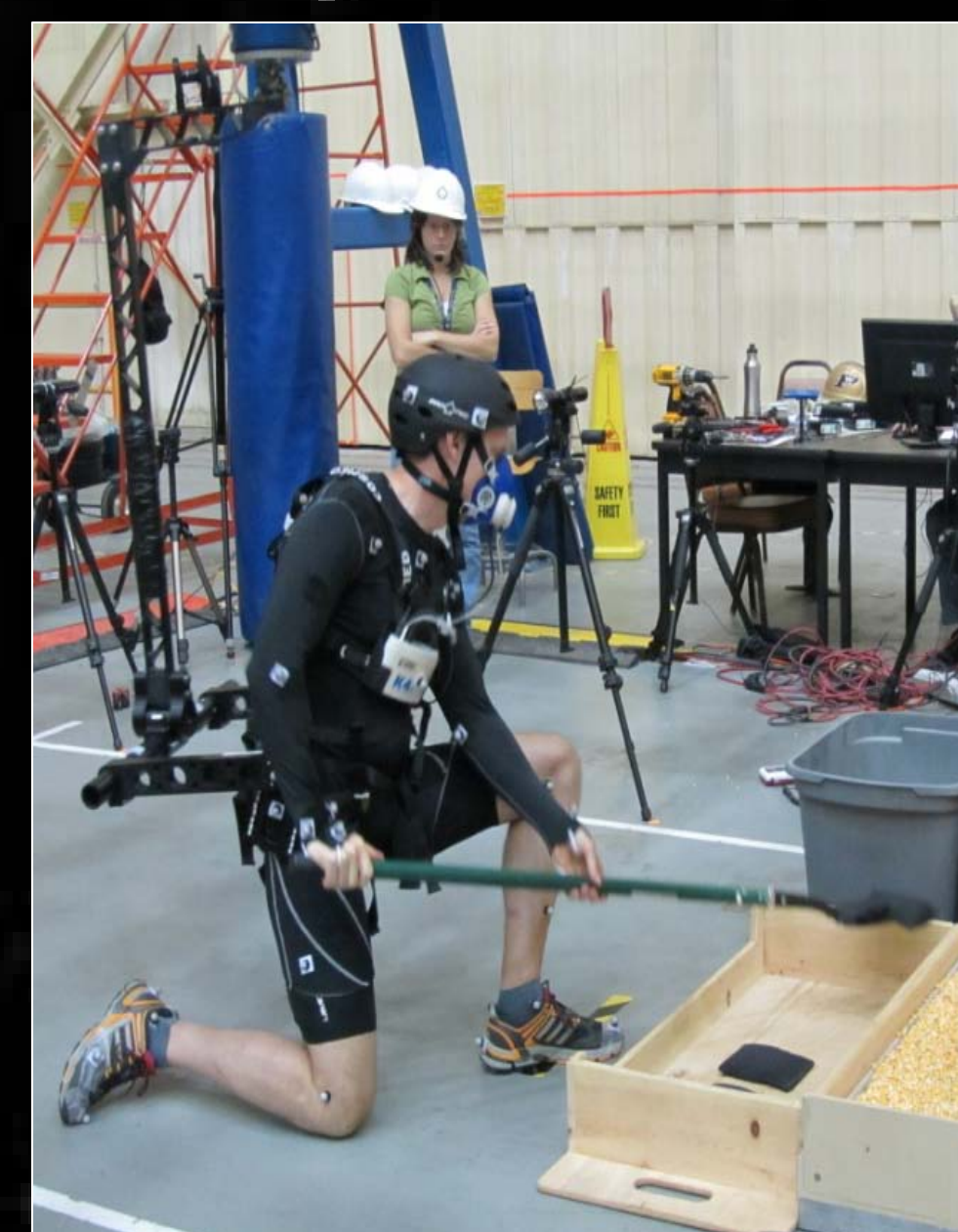
Incline Walking



Weight Transfer



Shoveling



## RESULTS

Statistically significant metabolic differences were noted between all 3 gravity levels for treadmill running and incline walking. For the other 3 tasks, there were significant differences between 1-g and each reduced gravity, but not between 1/6-g and 3/8-g. For weight transfer, significant differences were seen between gravities in both trial-average VO<sub>2</sub> and time-to-completion with noted differences in strategy for task completion.

## DISCUSSION

Of the five tasks tested, treadmill running and incline walking showed the greatest differences between gravity levels. This is likely due to the greater amount of force required in the vertical axis to complete the task. As gravity level decreased, the vertical forces required to maintain speed and grade were diminished and thus metabolic rate decreased. The differences seen between conditions while walking were statistically significant between 1-g and the reduced gravity levels, but were not practically significant, at > 3.5 ml/min/kg (1). At walking speeds, there is little vertical force other than what is needed to support body weight. This in combination with the expected lower metabolic rates required to walk showed that walking may not be affected significantly by gravity at shirt-sleeve conditions and may not be a discriminatory task for gravity comparisons. Shoveling was affected by the limitations of the gimbal interface to the ARGOS. Although there was a significant difference between 1-g and the reduced gravities, the strategy employed during the 1/6 and 3/8-g trials was unexpected. Subjects chose to lunge and stay at the bottom of the lunge during the reduced gravity trials because they would tip over if they tried to stand on their feet. This is likely due to the inability of the gimbal interface to maintain the center of gravity of the subject in line with the lifting cable and subject's feet. When these forces are misaligned, the subject is forced to adjust his/her posture in order to prevent falling forward. To the extent that shoveling is affected by gravity rather than the ARGOS or gimbal, we cannot say. The weight transfer task showed little difference in total metabolic cost, but the strategy employed to complete the task was notably affected by gravity. As gravity decreased, subjects required more time and expended less energy per minute to complete the tasks. To what extent any of these tasks will be affected by an EVA suit is unclear, but it is likely that a task which shows significant differences while unsuited, will likely continue the same trend in the suited condition.

## CONCLUSION

To determine if gravity level has an effect on the metabolic performance of EVA tasks, this research may indicate that tasks should be selected that require the subject to work vertically against the force of gravity. For non-steady state tasks, an additional measurement such as time to completion is important to evaluate performance as metabolic rate/cost alone may not be sufficient.

## REFERENCES

<sup>1</sup> Norcross JR, Lee LR, Clowers KG, Morency RM, Desantis L, De Witt JK, et al. Feasibility of Performing a Suited 10-km Ambulation - Final Report of the EVA Walkback Test (EWT). NASA/TP-2009-214796. Washington D.C.; 2009

